

CLAIMS

What is claimed is:

1. A method comprising:
deriving a ventilation related parameter in real-time from a patient;
deriving apneic intervals from the parameter;
distributing the apneic intervals as counts on a histogram; and
calculating a centroid for each cluster of counts on the histogram.
2. The method as recited in claim 1, wherein deriving apneic intervals comprises:
determining a value for each ventilation cycle based on the parameter;
filtering the values using a threshold value to separate values representing normal ventilation cycles from values representing apneic ventilation cycles; and
measuring the apneic intervals between the filtered values representing periods of normal ventilation.
3. The method as recited in claim 2, wherein the parameter comprises variations in thoracic impedance in response to breathing.
4. The method as recited in claim 3, further comprising normalizing the variations in thoracic impedance.
5. The method as recited in claim 3, further comprising normalizing the variations in thoracic impedance by differentiating the variations.

6. The method as recited in claim 2, wherein the parameter comprises one of chest movements in response to breathing, variations in air pressure in response to breathing, or variations in tidal volume in response to breathing.

7. The method as recited in claim 2, wherein determining a value for each ventilation cycle comprises determining a valley-to-peak magnitude for each ventilation cycle, wherein a respiratory expiration comprises a valley and a respiratory inspiration comprises a peak.

8. The method as recited in claim 2, wherein determining a value for each ventilation cycle comprises calculating a rate of change of the ventilation related parameter at regular intervals and summarizing the calculated rates of change during each ventilatory cycle using a single value.

9. The method as recited in claim 2, wherein the threshold value for filtering the values comprises one of: a mean of the values; an average of the values; a moving average of the values; a standard deviation from the mean for the values; a multiple of a standard deviation from the mean for the values; or a value derived from medical definition of apnea.

10. The method as recited in claim 9, further comprising measuring a time interval between two of the centroids.

11. The method as recited in claim 9, further comprising measuring a time interval between two of the centroids and diagnosing apnea based on the time interval.

12. The method as recited in claim 1, further comprising recomputing the one or more of the centroids at regular intervals.

13. The method as recited in claim 12, wherein the regular interval is daily.

14. The method as recited in claim 12, further comprising tracking the patient's health based on changes in the centroids due to the recomputing.

15. The method as recited in claim 1, further comprising performing the method in real-time.

16. An implantable device, comprising:
pacing circuitry to apply pacing pulses to a patient's heart via an electrode; and
a controller configured to collect ventilation related data from the patient over time and generate, based on the ventilation related data, a histogram that exhibits evidence of apneic episodes experienced by the patient.

17. The implantable device as recited in claim 16, further comprising means for tracking a patient's ventilation cycles in real-time and means for assigning a value to each ventilation cycle based on an extent of inspiration and expiration during each ventilation cycle.

18. The device as recited in claim 16, further comprising means for removing drift from the ventilation related data.

19. The device as recited in claim 17, wherein the means for assigning a value to each ventilation cycle based on an extent of inspiration and expiration during each ventilation cycle further comprises means for calculating a rate of change of the ventilation related data for each ventilatory cycle.

20. The implantable device as recited in claim 16, further comprising means for filtering the values using a threshold value to separate values representing normal ventilation from values representing apneic ventilation.

21. The implantable device as recited in claim 16, further comprising means for measuring apneic intervals between filtered values representing normal ventilation.

22. The implantable device as recited in claim 21, further comprising means for distributing the apneic intervals as a histogram.

23. The device as recited in claim 21, further comprising means for calculating a centroid for each cluster of the apneic intervals distributed as a histogram, wherein a position of a centroid on the histogram indicates an aspect of the patient's health.

24. The device as recited in claim 21, further comprising means for measuring a time interval between centroids for clusters of the apneic intervals distributed as histogram counts, wherein the time interval indicates an aspect of the patient's cardiopulmonary condition.

25. The device as recited in claim 22, further comprising means for updating the histogram at regular intervals.

26. The device as recited in claim 23, further comprising means for tracking a cardiopulmonary health of a patient based on movement of one or more of the centroids over multiple updates.

27. A ventilatory histogram engine, comprising: ✓
a ventilatory cycle tracker, to detect cycles of respiratory inspiration and expiration;
an apneic interval calculator to derive durations of apnea episodes from the cycles; and
a histogram array to store apneic intervals as counts on a histogram.

28. The ventilatory histogram engine as recited in claim 27, further comprising a centroid engine to recognize clusters of apneic intervals in the histogram array and calculate a centroid for each cluster.

29. The ventilatory histogram engine as recited in claim 28, further comprising a trend evaluator to determine changes in one or more of the centroids.

30. The ventilatory histogram engine as recited in claim 27, further comprising a cycle normalizer to remove wave artifacts from the detected cycles.

31. The ventilatory histogram engine as recited in claim 27, further comprising a cycle quantifier to determine a value for each of the cycles, wherein the cycle quantifier calculates a rate of change of a ventilation related parameter for each ventilatory cycle and wherein rates of change for multiple ventilatory cycles can be compared to distinguish normal breathing from periods of apnea.

32. The ventilatory histogram engine as recited in claim 27, further comprising a filter to separate values of the detected cycles based on a threshold value, wherein the threshold value separates values representing normal breathing from values representing apneic breathing.

33. The ventilatory histogram engine as recited in claim 27, wherein the apneic interval calculator derives durations of apnea episodes from values of detected cycles representing normal breathing.